RANCHI UNIVERSITY, RANCHI

SYNOPSIS

Submitted
On

"GEOLOGICAL AND GEOCHEMICAL ASPECTS OF MICA-PEGMATITE DEPOSITS IN AND AROUND PIHRA AND TISRI AREAS OF GIRIDIH DISTRICT, JHARKHAND WITH SPECIAL EMPHASIS ON ITS POTENTIALITY FOR CRITICAL AND STRATEGIC MINERALS"

For the degree of

DOCTOR OF PHILOSOPHY (Ph.D.)

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1. INTRODUCTION

The Climate Action entitled "Take urgent action to combat climate change and its impacts" is one of the 17th agenda of the "Sustainable Development Goal (SDG)-2030" adopted in 2015 by all Member States of the United Nations. Accordingly, India has set its target to achieve Net Zero for carbon emissions by 2070. The Indian Government has taken several measures to move from fossil fuel-based energy sources to non-fossil fuel-based or green energy sources to minimize the ecosystem's carbon footprint and achieve the net zero emission target. Recently, in January' 2025, the Indian Govt. has approved & announced "**National Critical Mineral Mission (NCMM)"** with an objective to secure India's critical mineral supply chain from domestic and foreign sources and to optimize the resource base of Critical & Strategic Minerals (**CSM**) through Innovation & skill development. NCMM aims to provide support in achieving India's target of "Viksit Bharat 2047" and "Net Zero Emissions by 2070".

In this context, thrusts are also being made across the country to explore and optimize the use of critical and strategic minerals such as Lithium (Li) and REE (Rare Earth Elements) as a green energy source. According to the U.S. Geological Survey, the largest portion of Li resources (~53%) is located in three South American countries, namely Argentina, Bolivia, and Chile. As of 2022, China contains the highest reserves (~34%) of REE and produces ~70% of total REE quantity in the world. In stark contrast, India contains only 6% of the world's REE reserves and produces ~1% of total global output. As far as Li resources are concerned, the exploration, extraction, and beneficiation techniques of lithium from Li-bearing minerals such as Spodumene and Lepidolite are in the nascent stage in India. Recently, the Geological Survey of India (GSI) has discovered ~5.9 million tons of Li resources in the Salal-Haimana area, Jammu and Kashmir.

Jharkhand containing about 40% of India's natural mineral resources also has huge potential for Li and REE resources particularly in the granitic mica-pegmatite deposits occurring at several places of the State such as Giridih, and Koderma. Since long, Koderma district is well known for Mica mining in the country. Other important minerals available in the district are Quartz, Feldspar, Soapstone, Quartzite, Decorative Granites and precious and semi-precious variety of Moon stone, Tourmaline, Garnet, Citrine, Amazonite, Beryl, Andalusite, and Rose Quartz. Geochemical mapping in and around Tilaiya block of Koderma district of Jharkhand

has revealed high concentrations of lithium, cesium and other minerals. In view of this, Pihra and Tisri areas of Giridih district, Jharkhand have been considered as my research area.

2. LOCATION AND ACCESIBILITY

The study area belongs to the Archean-Proterozoic period. The area is located in Villages-Pihra and Asurhaddi, Blocks- Gawan and Tisri of Giridih District, Jharkhand, Eastern India. It falls under the Survey of India OSM sheet No. G45T14. The study area is bordered by latitude 24°42'33.64" to 24°43'14.89" N and longitude 85°56'17.60" to 85°58'21.06" E. The area is connected with all-weather roads and is located at about a distance of 80 km towards north-west from the District headquarter- Giridih which is also the nearest railway station from the area. The area is located at a distance of about 215 km from the State Capital- Ranchi towards NE direction.

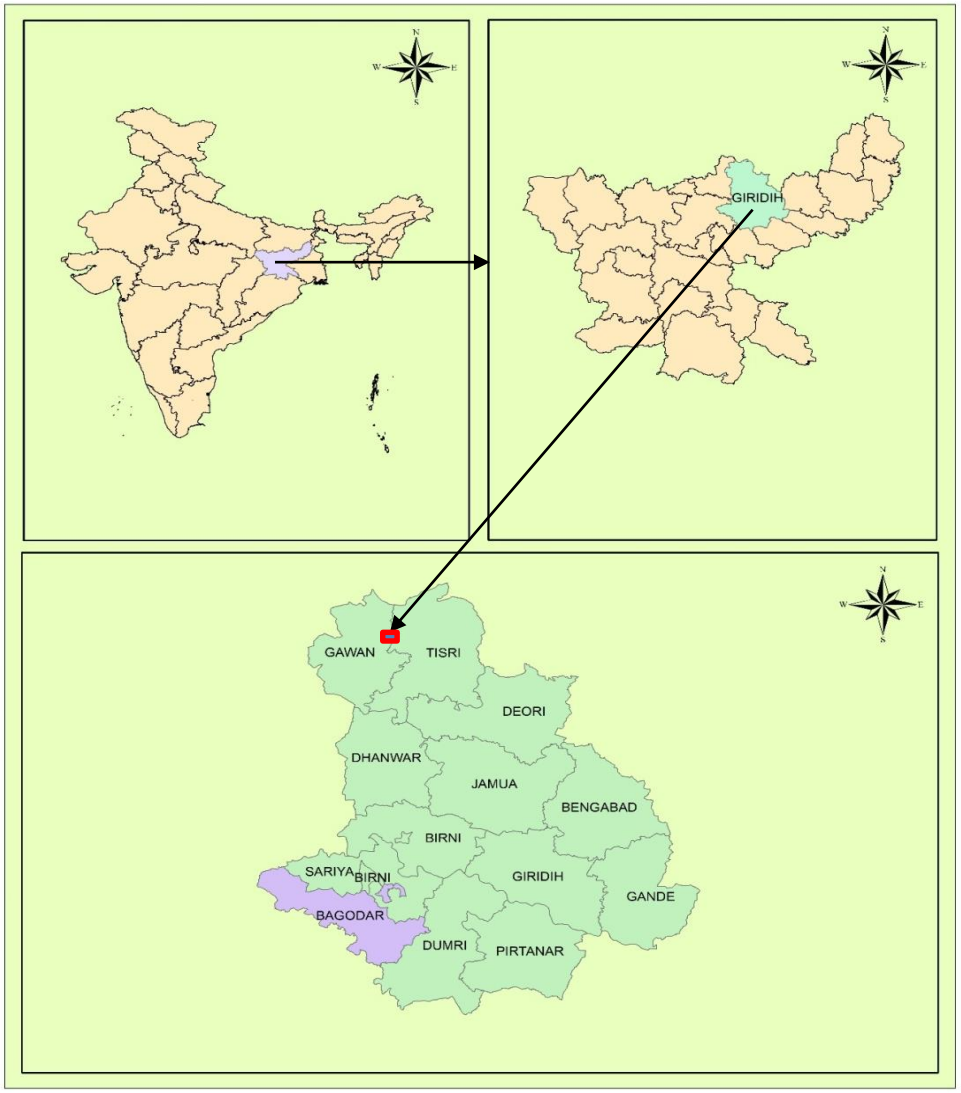

Fig. 1: Location map of the study area – Pihra-Tisri areas, Giridih District, Jharkhand.

3. OVERVIEW OF REGINAL GEOLOGY

Regionally, the study area is a part of "Bihar (Jharkhand) Mica Belt (BMB)". BMB runs E-W for ~150 km (width ~55 Km.) across the Giridih, Koderma & Hazaribagh districts of Jharkhand & Monghyr, Nawadah & Gaya districts of Bihar. It is mainly of Archean period and a metamorhic belt falling under Chhotanagpur Granite-Gneiss Complex (CGGC). Main rock type comprises Schist (*Muscovite-Biotite-schist, Mica-Quartz schist, Chlorite-Tremolite-Actinolite-Quartz schist, Hornblende-Amphibolite schist*), Gneiss, Granite, Amphibolite, Phyllite, Pegmatite & Quartzite (**Table-1; Figure-2**). Of these, Mica-Pegmatite consisting mainly of quartz, feldspar & mica tourmaline hosts numerous metallic & non-metallic minerals such as- Magnetite, Beryl, Rubyllite, Columbite-Tantalite, Garnet, Green Tourmaline (Elbaite), Lithium, REE and Rare Metals. The rocks show nearly E-W trending showing various structural features such as folds (with numerous subsidiary folds of different phases), joints, fractures, local faults, foliation & localized shear zones. The rocks are well foliated, puckered & exhibit metamorphic grade of "Almandine-Amphibolite Grade". Pegmatite are emplaced (955 ±50 Ma; closing stage of Satpura Orogeny) along joints, fractures, foliation, shear planes, noses and limbs of folds showing both concordant and discordant relationship with the country rocks (*Bhola K. L., 1986; Mishra S. et.al., 2002*).

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Table-1: Regional stratigraphic sequence of litho units (Source: after GSI)

Age	**Formation**
Post Gondwana	Dolerite
----------Unconformity----------	
Archaean (*Study area*)	Pegmatite and Quartz vein Granite (?)
	Granodioritic rocks
	Granite gneiss
	Amphibolite, Amphibole, pyroxene rocks and amphibole schists
	Schistose formations (quartz Mica) Schist, mica schist, hornblende schist, quartzites etc.

4. GEOLOGICAL OVERVIEW OF THE STUDY AREA

The proposed area chiefly consists of mica-pegmatite, schist, gneiss, quartzite, amphibolite and granite. The general strike of the exposed rocks is in the E-W direction which varies at places depending on several geological constraints. Pegmatites are composed of quartz, plagioclase feldspar, mica, black tourmaline, green tourmaline, and garnet. Micas of white, black, purple and green varieties have been noticed within the area. Field photographs of

some of these lithologies observed during preliminary field visit of the study area have been shown in **Figures-3** to **Figures-5**.

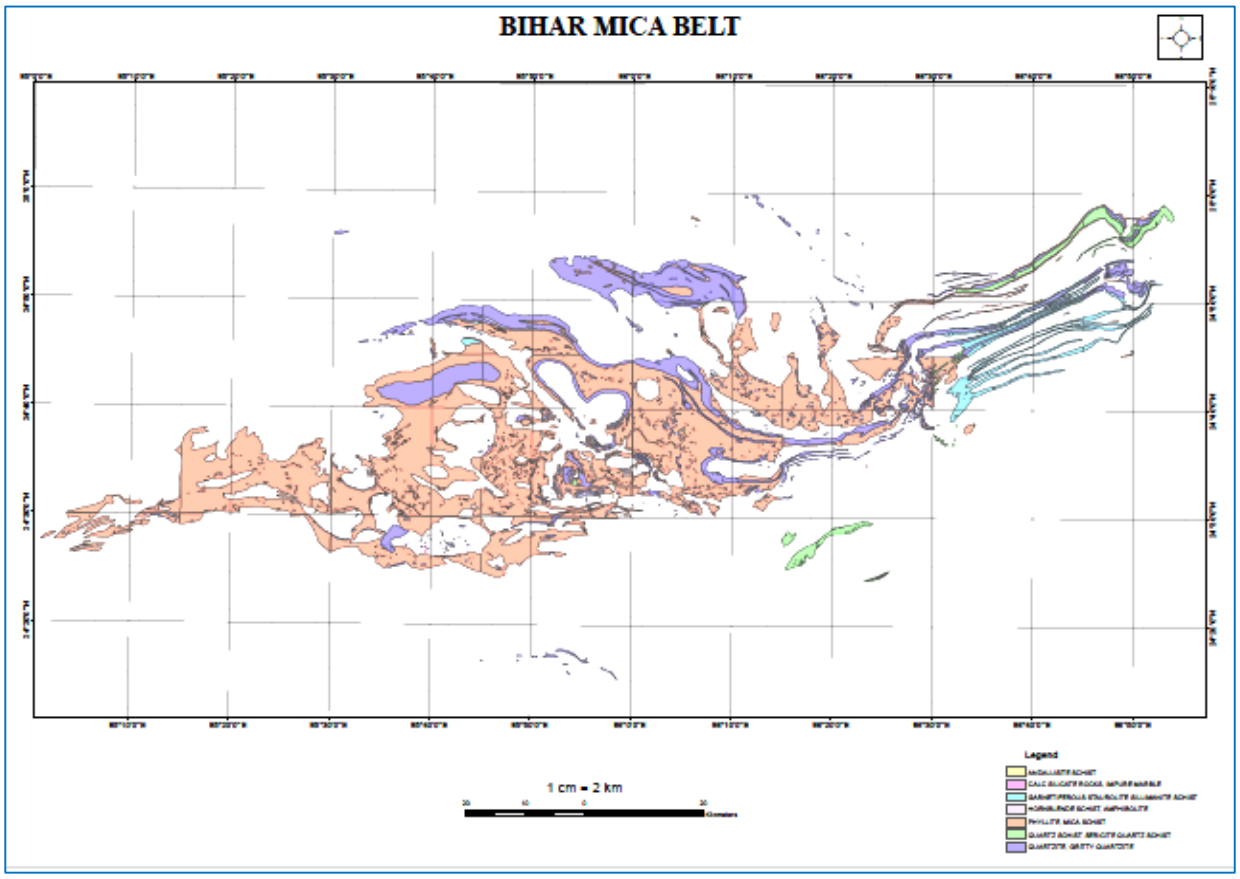


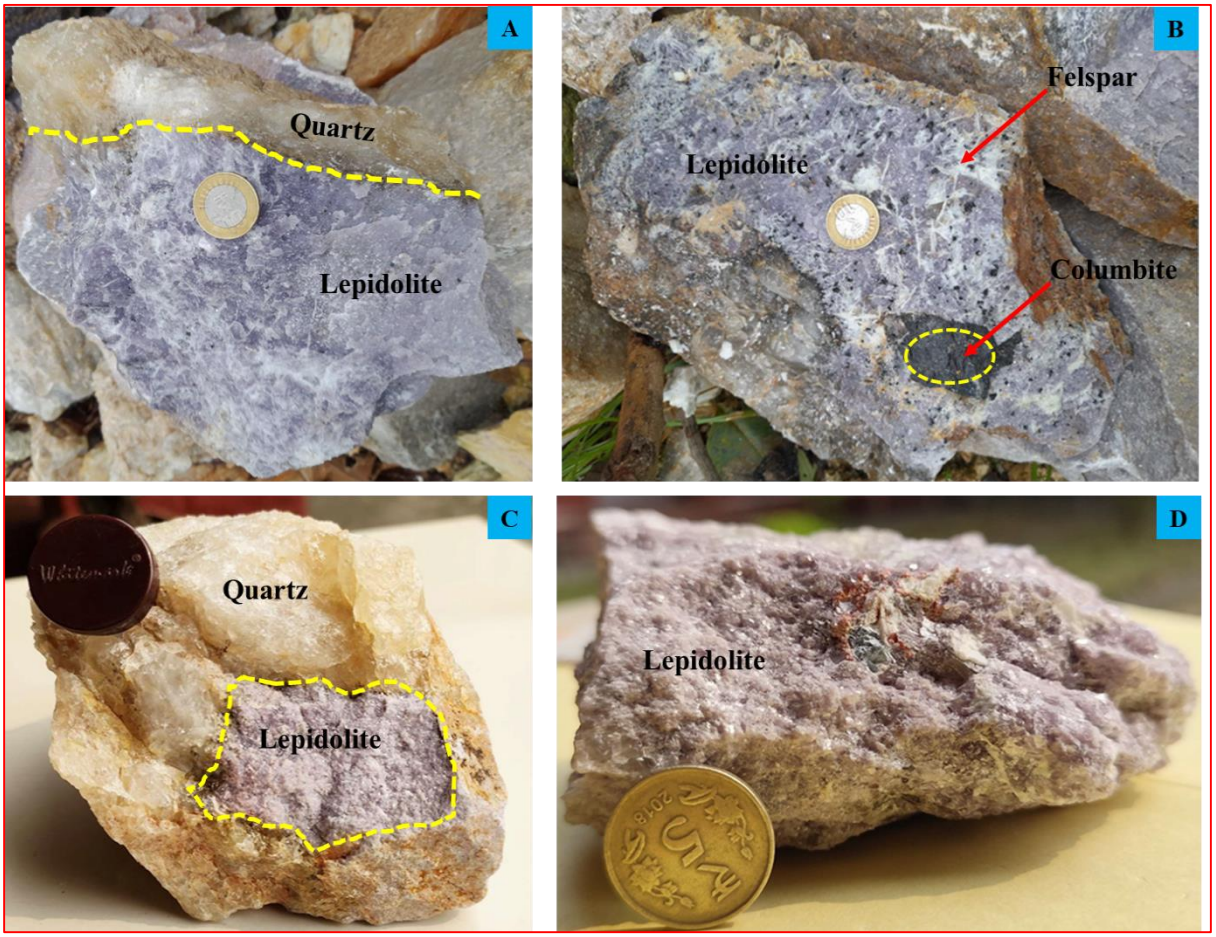
Fig. 2: Regional geological map of Bihar Mica Belt showing distribution of mica schist and various other lithologies in and around Pihra-Tisri areas, Giridih District, Jharkhand.

5. REVIEW OF THE PREVIOUS WORK

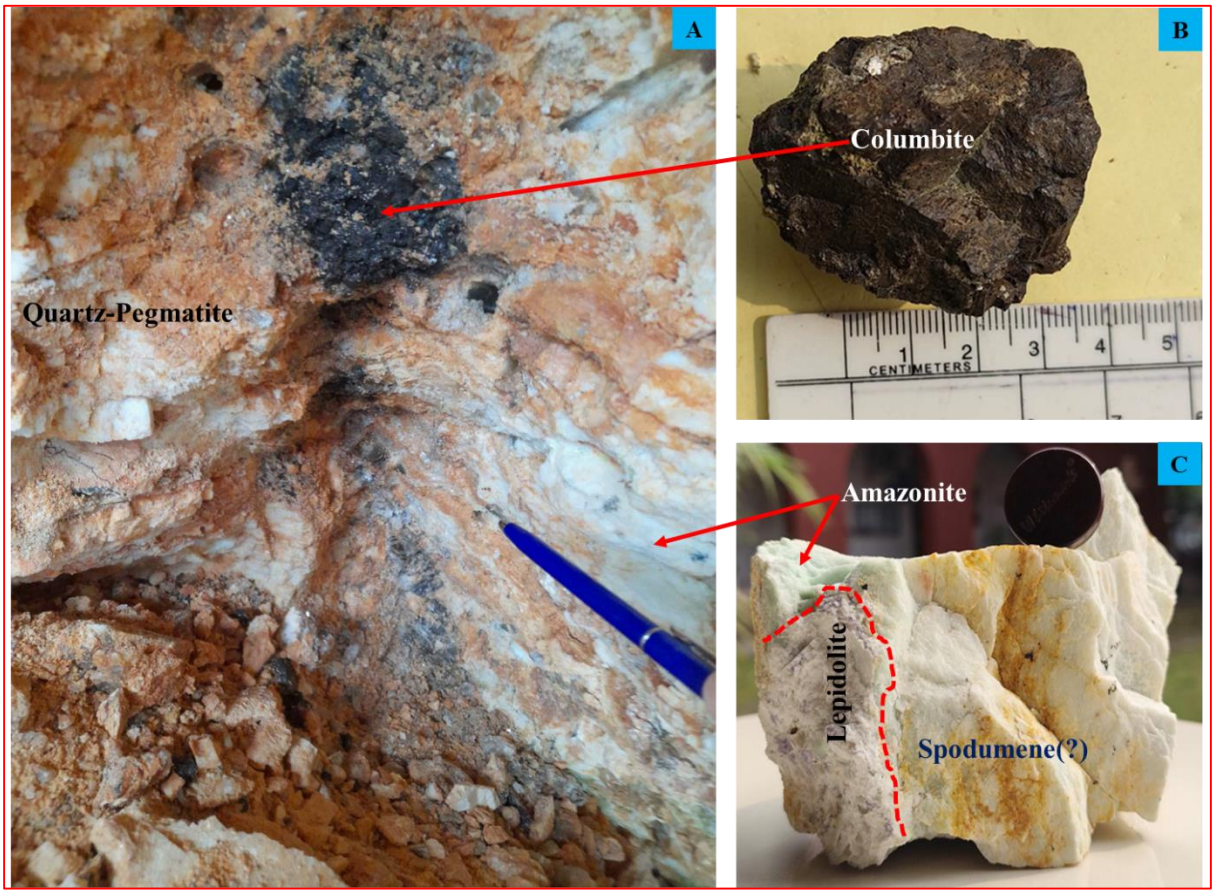
The Bihar Mica Belt has been always known for its vast reserve of mica and many other precious and semi-precious minerals. K. L. Bhola (1968) has studied Bihar Mica Belt in view of Atomic and other mineral prospects. Recently in 2024, studies have been made by Kumar Abhinay and Dewashish Upadhyay regarding "Zircon U-Pb-Hf constraints on the geological evolution of the Bihar Mica Belt with its link to Columbia Assembly". Numerous other geoscientists and pioneer workers from GSI, MECL, AMD and the Directorate of Geology, Department of Mines and Geology, Governemnt of Jharkhand have carried out geological as well as exploration works in and around Giridih-Koderma Mica belt. Recently, Directorate of Geology, Governemnt of Jharkhand has carried preliminary exploration works in Koderma-Giridih Mica Belt in view of Lithium and REE resources. However, detailed exploration and

feasibility study are yet to carry out regarding prospects of Li, REE and Rare Metal occurrences in Koderma-Giridih Mica Belt. Hence, the present research work focuses on in-depth geological studies of mica-pegmatite deposits of the proposed study area with special emphasis on occurrence of critical and strategic mineral (**CSM**) prospects.

Figs. 3: Field photographs showing: **A**) The area under investigation- Asurhaddi-Duba Li & associated Rare Metal block in Giridih District, Jharkhand; **B**) A close-up view of Mica schist showing a general trend of foliation planes along East-West direction; **C**) A panoramic view of Amphibolites exposed as scattered boulders near Duba area of Giridih District; and **D**) A close-up view of Amphibolites with dark coloured and mainly consisting of Hornblende and Felspar.



Figs. 4: Hand specimens collected during Field investigation showing: **A**) A close-up view of Li-bearing Mica- Lepidolite with light purple in colour closely associated with Quartz-Pegmatite; **B**) Lepidolite Mica showing occurrence of Quartz, Felspar and Columbite. Note that on the basis of field and laboratory studies, the pegmatite of the investigated area can be classified as Li-Cs-Ta (LCT)-Type Pegmatite as they are enriched in rare metals like Lithium, Cesium and Tantalum. Chalcopyrite along foliation planes; **C**) Li-bearing Mica-Lepidolite with light pink to purple colour occurring as intrusive dyke/veins within Quartz-Pegmatite; and **D**) Coarse-grained Lepidolite Mica occurring in the form of small flakes.



Figs. 5: Field photographs showing: **A**) An exposure of Pegmatite exposed within an old pit of the Asurhaddi area showing occurrence of Quartz, Felspar, Muscovite, Columbite (black coloured) and Amazonite (light green coloured); **B**) A close-up view of Columbite recovered from Li-bearing Pegmatite zone; and **C**) Li-bearing Mica- Lepidolite in close association with Amazonite. Note that the lithology in whitish colour occurring in close association with Lepidolite seems as Spodumene (?). However, the same will be confirmed after further detailed petrographic and laboratory studies.

6. RESEARCH GAPS

Though, several studies have been made on Mica-Pegmatite Deposits of Bihar Mica Belt by numerous Geoscientists. However, types of pegmatite whether LCT (Lithium-Cesium-Tantalum)- type or Non-LCT, its emplacement in the host rock, source fluid of pegmatite and time correlation between granite and pegmatite are some of the areas which are debated, not well established and still requires detailed study. Also, potentiality of the area in terms of

CSM like Li/REE/RM is not well known in view of its economic utilization for green energy sources and energy transition. Hence, during my present research work, attempts will be made to bridge these study gaps in order to help exploration agencies and miners to make strategies for further detailed exploration and economic extraction of CSM in the State.

7. OBJECTIVES OF THE PRESENT WORK

The objectives of the present work over the study area include:

- Study of regional and local geology of the area for understanding overall geological set-up of mineralization.
- In-depth studies of various lithological & structural features with a view to decipher their role on the controls of the mineralization.
- Geochemical characterization to understand petrogenesis, depositional environment & to develop a possible ore genetic model.
- Detailed ore mineralogical characterization and beneficiation studies in order to understand the mineralogical composition and to facilitate strategy for ore processing/ mineral recovery for economic utilization.

8. METHODOLOGY AND INSTRUMENTATION

In order to attain the aforesaid objectives as mentioned above, the following methodologies and analytical techniques will be applied**:**

- Extensive literature survey and data collection on geological, lithological and structural set up, geochemistry and mineralogy of the study area.
- Preparation of a geological map of the area through detailed field investigations in order to know important lithological units and structural features present over the study area.
- Collection of representative samples of minerals and associated rocks for chemical analysis and petrographic studies including detailed ore mineralogical characterization to know the composition and ore textural characteristics.
- Scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) or EPMA will be used to know various mineral phases.
- Major, trace and rare-earth element geochemistry of the host rocks and associated minerals using X-ray fluorescence spectrometry (XRF) and inductively coupled

plasma-mass spectrometry (ICP-MS) will be conducted to observe the elemental variation and to correlate different elements for possible geochemical evolution of mica-pegmatite deposits and associated minerals.

- Based on the mineralogical studies and ore mineralogical characterisation, possible mineral beneficiation/processing techniques will be outlined.
- Interpretation of the chemical data to develop a genetic model for mineralization.

9. SIGNIFICANCE & RELEVANCE OF THE PRESENT STUDY

The theme of present research work entitled "Geological and Geochemical Aspects of Mica-Pegmatite Deposits in and around Pihra and Tisri Areas of Giridih District, Jharkhand with Special Emphasis on its Potentiality for Critical and Strategic Minerals" has been aimed at understanding and addressing every geological and geochemical aspects in details. These studies will prove to convert the potential "mineralized zones" into "proved reserves" and to know the potentiality of the study and adjoining areas in terms of deposits of critical and strategic mineral commodities. Also, it will pave the way to formulate strategies for further detailed exploration as well as economic extraction of these minerals in the State.

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